made either a voiced command or a silent gesture command during the time interval when the microphone received the sound input **230**.

[0065] The device **222** further includes a bioauthentication circuit **236** configured to authenticate whether a voiced command or a silent gesture command arose from the user. The bioauthentication circuit **236** may be part of, or work in conjunction with, a processor **238** included in the device **222**.

[0066] One such authentication may be to accept a voiced command recognized in the microphone's output signal only if the analysis of the self-mixing interferometry signal confirms that the user was speaking when the microphone received the sound input **230**. In another type of authentication, a voiced command recognized in the microphone's output signal is accepted only when it agrees with a voiced command recognized in skin deformation information of the self-mixing interferometry signal. These two types of authentication can reduce improper command entry to the device **222**, such as from a recording of the user's voice, or from another person's voice.

[0067] In still another authentication, a silent gesture command recognized in skin deformation information of the self-mixing interferometry signal may be accepted as valid if the sound input **230** occurring concurrently with the skin deformation is below a volume threshold, such as when the user is not speaking and the background noise is low.

[0068] The bioauthentication circuit **236**, and/or its associated processor **238**, may store voice patterns from the user for recognizing and/or authenticating voiced commands. The voice patterns of the user may have been entered into the device **222** during an initial training session, or may be obtained during usage of the device **222** by use of learning algorithms. A voice signal recognized in the microphone's output signal may only be accepted as a valid input command to the device **222** when it is found to match a stored voice pattern of the user.

[0069] FIG. **2**C shows a block diagram of an additional and/or alternative configuration **250** that may extend the configuration **200** of FIG. **2**A or **2**B. The configuration **250** includes a wearable device **252** that can attach to a user's head **256** by means of a connection component **254**. Particular devices that may make use of the configuration **250** will be described below, with two examples shown in FIGS. **3**A-B. As in the configuration **200** of FIG. **2**A, the device **252** includes a self-mixing interferometry (SMI) sensor **262**, as described above, configured to emit a beam of light **258***a* toward a location on the user's head **256**, and receive reflections **258***b* from the location. The reflections **258***b* may cause a light source in the SMI sensor **262** to undergo self-mixing interference. The self-mixing interference may be detected in a self-mixing interferometry signal of the SMI sensor **262**.

[0070] As with the device **222**, the device **252** includes a microphone **264** operable to detect sound input **260**, which may be a voiced command of the user, or originate from another sound source, such as another person, a music source, or from background noise. The microphone **264** may perform an initial filtering or signal conditioning on the received sound input **260**, and may produce a corresponding output signal having an alternate format, such as a digital encoded format. The microphone **264** allows the device **252** to use sensor fusion, in which both an output signal of the microphone **264** and the self-mixing interferometry signal from the SMI sensor **262** are both used to detect a user input.

[0071] The device **252** includes an audio conditioning circuit **266** configured to receive both the output signal of the microphone **264** and the self-mixing interferometry signal from the SMI sensor **262**. The audio conditioning circuit **266** may be part of the processor **268**, or may work in conjunction with the processor **268** to analyze the output signal of the microphone **264** and the self-mixing interferometry signal from the SMI sensor **262**. The audio conditioning circuit **266** may perform bioauthentication operations, such any of those described above.

[0072] The audio conditioning circuit **266** may be configured to perform various operations using the combination of the self-mixing interferometry signal and the output signal of the microphone **264**. In one such operation, the audio conditioning circuit **266** and/or its associated processor **268** may have stored various voiced commands of the user. The audio conditioning circuit **266** may use the self-mixing interferometry signal and a concurrently received output signal to determine an intended voiced command from among the stored voiced commands of the user. The matched voiced command may then be transmitted by the audio conditioning circuit **266** and/or its associated processor **268** to an electronic device associated with the device **252**. For example, the device **252** may be the earbud **300** described below, and may be linked by a Bluetooth connection with a cellphone. By transmitting the matched voiced command, noise in the received sound input **260** would not be further transmitted.

[0073] In a second operation, the audio conditioning circuit **266** may determine that the output signal from the microphone **264** is below an amplitude or volume threshold. However, the audio conditioning circuit **266** may detect that the user was making a silent gesture command based on the self-mixing interferometry signal. The silent gesture command may be matched with a stored voiced command of the user, and that stored voiced command may be transmitted to an associated electronic device. For example, the device **252** may be the earbud **300** below. A user may inaudibly form words with jaw motions, such the words or numbers of a passcode, to maintain privacy. While only background noise may be detected by the microphone **264** in the sound input **260**, the audio conditioning circuit **266** may detect the formed words in the skin deformation information in the self-mixing interferometry signal. Then the stored voiced command may be transmitted to a cellphone linked with the earbud.

[0074] In a third operation, the audio conditioning circuit **266** may use signal processing algorithms, such as weighted averaging, applied to a concurrently received sound input **260** and a self-mixing interferometry signal. The signal processing may remove noise, strengthen or interpolate for inaudible sections in the received sound input **260**, or perform other operations.

[0075] The audio conditioning circuit **266** may perform other or alternative operations in addition to or instead of the operations described.

[0076] Details of four specific examples of wearable devices that may implement the configurations described above are now presented, along with further processes or operations they may perform. However, it is to be understood that other wearable devices are within the scope of this disclosure.